

Sadara Chemical Company

An ISO 50001:2018 certified company in 2022. In 2023, achieved the Overall Site energy intensity reduction of 4.1%, ahead of the 2025 target year, and awarded by GPCA with the ‘Sustainable Environmental Protection Award’ for its Sustainable Energy on Waste Heat Recovery.



Figure 1. Sadara Mixed Feed Cracker (MFC)

Case Study Snapshot	
Industry	Petrochemical
Product/Service	Basic Chemicals, Plastics, Isocyanates
Location	Saudi Arabia
Energy performance improvement percentage (over the improvement period)	4.1% improvement over 3 years
Total energy cost savings (over the improvement period)	USD 6,569,127.00
Cost to implement Energy Management System (EnMS)	USD 67,332.00
Total energy savings (over the improvement period)	4,172,346.62 MWh
Total CO₂-e emission reduction (over the improvement period)	624,219.88 Metric Tons CO ₂ -eq

Organization Profile / Business Case

The Sadara Chemical Company represents a unique alliance between two corporate leaders in their respective industries – Saudi Aramco and The Dow Chemical Company – brought together through shared values and a dedicated vision to create a game changer in the chemical industry in the region.

In 2017, Sadara began full commercial operations of its chemical complex, in Jubail Industrial City, Saudi Arabia – the first-of-its-kind world’s largest ever complex built in a single phase. The mega complex consists of 26 manufacturing plants, with an annual production capacity of over 3 million metric tons of value-adding chemicals and plastics. Sadara is committed to Sustainability, and energy management is an integral part of fulfilling our Sustainability strategy. We consider the impact across the supply chain, to our stakeholders, and to the environment.

EnMS drivers. Sadara initiated the energy management system (EnMS) in 2021 as part of the business model and is driven mainly by our Sustainability Program which considers the country’s Vision 2030 applicable requirements, the applicable United Nations Sustainable Development Goals (UN SDGs), the Saudi Green Initiative (SGI), the Ministry of Energy’s Saudi Energy Efficiency Center (SEEC)’s framework and other applicable requirements. EnMS started as an identified initiative of the Sustainability team as part of the department goals, which was supported and approved by Top Management, to systematically address energy performance improvement and compliance to the government and stakeholder requirements.

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EnMS scope. The ISO 50001:2018 EnMS certificate covers the entire complex as a single facility.

Establishing the EnMS. Sadara established the EnMS using the available resources internally and with the help of the government i.e., SEEC and peers in the industry in the Jubail Industrial City. Implementing EnMS took 2 years of journey until Sadara obtained the ISO 50001:2018 certification. In a nutshell, Sadara developed a 4-stage process towards certification. It started with (1) Leadership engagement (established the energy policy & Sustainability council), (2) task force formation (developed the team charter, accounting methodology, and competency development), (3) EnMS Implementation (developed the EnMS standard, calculation templates, energy review & operational control templates, and improvement plan execution, and others, see Figure 6 for the work process), and (4) engaging the 3rd party consultant to conduct gap analysis of the EnMS, auditor training, and stage 1 & 2 audits).

Sadara has assigned a plant focal point, for each of the 26 manufacturing plants, including the supporting units such as the Maintenance, Procurement, and Engineering, based on their qualification, training and experience. The energy team charter has defined their roles and responsibilities and activities such as data submission and periodic meetings, including the identification of specific EnMS objectives and targets.

Strategic objectives and targets. The strategic goals of the EnMS include energy performance improvement, natural resource conservation, compliance to our stakeholder requirements, and EnMS continual improvement. The specific EnMS objectives and targets include the reduction of the Overall site energy intensity by 2.5% in 2025, meeting the regulatory targets by 2025, establishing initiatives and projects for energy performance improvement annually, completing the data assurance and audits annually, conducting measurement & verification periodically, competency enhancement of our designated facility focal points annually, including awareness on energy users, and comply with the ISO 50001:2018 requirements. These objectives and targets are documented in the team’s charter and approved by the Sustainability Council (refer to Figure 2).

EnMS and business strategy. To understand the role of EnMS and how it relates to the Sadara’s business strategy, EnMS risks and opportunities were identified and classified according to 5 company risks categories: Strategic, Financial, Compliance, Operational, and Environmental. The identified energy risks and opportunities (RO) are logged in the standard Sadara RO register. Minimizing and/or preventing risks is important in business continuity, and mitigation measures have been identified for the risks while potential opportunities are evaluated and explored.

EnMS is integrated and monitored as part of Sadara Sustainability’s 3rd pillar on Climate Change & Natural Resource Conservation. Moreover, it has been embedded in Sadara’s Operating Discipline Management System (ODMS) which contains policies, requirements, processes, best practices, and procedures associated with EH&S, Quality, Operations and related external standards. Use of this system ensures compliance, achieves objectives, and targets and improves performance results.

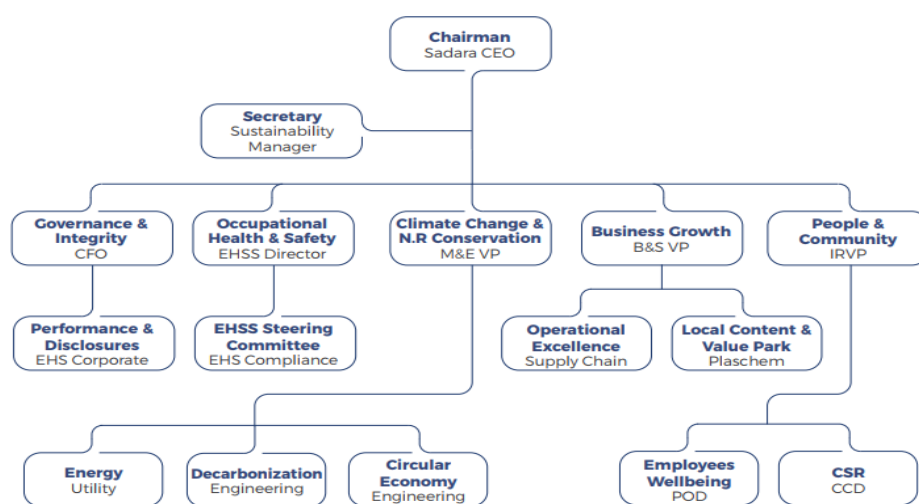


Figure 2. Sadara Sustainability Council

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As energy efficiency is linked to carbon emission reductions, a dedicated Decarbonization team works together with the EnMS team to meet the energy and greenhouse gas (GHG) emission reduction targets until Net Zero 2050. Additionally, EnMS improvement initiatives are supported further by the Sadara Transformation Program.

“ISO 50001 helped Sadara in establishing effective framework to support us in achieving our energy goals and optimization in managing our energy resources, which in return helps mitigate climate change, and also improve energy efficiency within our operations.”

—Salamah AlDhafiri, EH&S Corporate Director

Business Benefits

Since the inception of the EnMS, Sadara has continually improved in energy performance and a culture of energy consciousness has been observed. With Sustainability and compliance as the main drivers, the behavior of employees that impact energy performance has developed from mere monitoring to a more conscious and KPI-driven and continual improvement mindset. The engagement from plant leaders to middle management has increased.

Energy performance improvement metric. Energy intensity (EI) is used as the target metric, which is normalized. Production is the relevant variable that impacts energy consumption. Other monitoring metrics are used such as the fuel intensity, steam intensity, power intensity, and absolute energy savings is used on a plant level basis.

Sadara steady state operation is based on a 24/7 yearly work schedule, with periodic planned shutdowns and turnarounds.

Energy & GHG performance. Sadara’s EnMS performance has led to achieving the Overall site EI reduction of 4.1% in 2023 compared to the base year of 2020, and surpassing the 2025 target of 2.5%. The absolute energy consumption reduction in 2023 compared to 2020 is at 15,020,436 GJ (equivalent to 14,236,624 MMBTU or 4,172,346,620 kWh). Equivalently, the absolute GHG emissions reduction in 2023 compared to 2020 is 624,220 metric tons of CO₂-eq, which is 11% GHG reduction. Figure 3 further illustrates the trend in the EI and absolute energy consumption from 2020 to 2023.

To demonstrate an example of how EnMS worked on an operational level, Sadara has improved the performance of the waste heat recovery (WHR) systems by optimizing the steam generated.

Clean energy on Waste Heat Recovery systems. Sadara is harnessing waste heat to produce steam using 3 technologies: (1) via feedstock cracking, (2) utilizing heat of exothermic chemical reaction, and (3) on-site organic liquid and waste gases thermal oxidation (THROX). For the THROX, maximizing waste heat required finding the right reactor parameters and ensuring that right proportions of the 46 liquid and gas wastes to maintain optimized thermal oxidation, which took 1 - 3 years after startup. Combining all of these WHRs led to savings in steam amounting to a generation rate of 12% of the overall site steam demand.

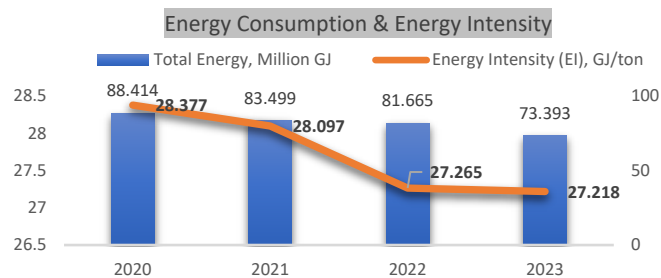


Figure 3. Sadara energy performance KPIs

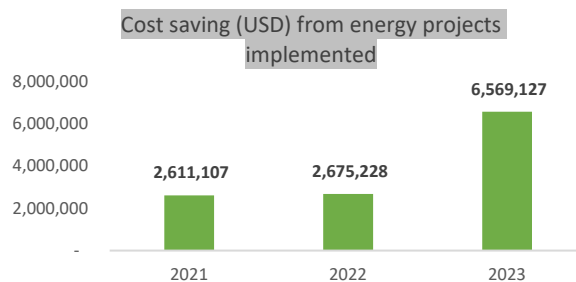


Figure 4. Annual Energy Savings excluding WHRs

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In 2023, WHRs combined generated 1.53 Million metric tons of steam and is distributed to steam users across the complex. Collectively, this innovative strategy eliminated the need to use 109,658 tonnes of mixed fuel for steam generation, curbed evolution of direct GHG emissions of 326,352 tonnes CO₂-eq, eliminated the disposal of site specific wastes, and prevented associated risks in off-site waste transportation and disposal.

Energy savings and investment costs. Since the beginning of the EnMS program, the energy team has identified 59 energy improvement projects until 2025. In 2023, the accumulated energy savings (excluding WHRs) is estimated at 6,569,127 USD (Figure 4). These initiatives are categorized based on fuel reduction, power optimization, and steam optimization. The total investment cost for 2020 – 2023 is 1,606,250 USD.

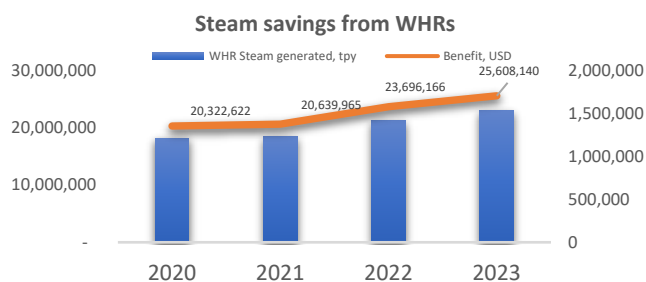


Figure 5. Estimated Steam savings (USD) from WHRs

The steam savings from WHRs steam generation is shown on Figure 5, ranging from 32 to 40 Million USD annually. There was no extra investment required in the WHRs, only optimized operational control to maximize the steam generation. The overall energy cost savings are 75 – 100% due to operational cost savings. To make these energy savings possible, other EnMS activities are in place to ensure that the energy focal points are trained, documentation is adequate & correct, and 3rd parties suppliers are engaged.

Trainings, documentation, & suppliers. Sadara has sent energy focal points to various trainings and certifications such as the Certified Energy Manager (CEM), Certified Energy Auditor (CEA), and ISO 50001 lead auditor and ISO 50001 basic training course. Additionally, awareness sessions have been conducted across the site for personnel who impact energy performance. As a result of these trainings, EnMS documentation was formed. Documentation was one of the challenges in the certification journey, and by collaborating with the auditors, SEEC, and use of available resources i.e., standards, frameworks, best practices, the required documentation was developed and implemented. These documents include energy management standard, the energy review standard, energy audit standard, energy accounting protocol, and the team charter.

As part of holistic approach to EnMS, we engage with our 3rd parties such as Linde and the Saudi Hydrogen Peroxide Company (SHPCo). Our energy policy ensures that we work together to achieve energy efficiency on the energy streams that we import and export, including procurement of energy efficient materials.

Sadara achieved the **ISO 50001:2018 certification** in 2022 and the succeeding year the surveillance audit was conducted successfully. Maintaining the certificate has proven its usefulness to maintain the EnMS activities running, to continually improve our strategies and tools, and to continually demonstrate to our stakeholders of our commitment to energy efficiency, decarbonization, and circular carbon economy.

Plan

Sadara has a Sustainability Council (Figure 2) governing the Sustainability Program, and energy management is a part of this program. The council has defined role and responsibilities as per the charter and sets the commitments relevant to the Sustainability aspects and the CEO approves it. Periodic management system reviews (MSRs) and recommendations from the stakeholders paved the way to adopting the EnMS.

Management decisions are made on a periodic basis, including financial requirements for projects and other resources. Project approval and other activities such as trainings and audits are planned in the annual Business goals. Performance updates are provided to management on a monthly basis, and by year-end MSRs are done to determine the developments, challenges, strengths, and recommendation of continual improvement measures.

EnMS work process. To systematize the implementation of the EnMS, Sadara energy team has established the work process (see Figure 6) as detailed in the EnMS standard. This work process follows the ISO 50001:2018 requirements and incorporates the learnings from implementing it, which includes the relationship of one activity to another. The process starts from the energy policy, then the objectives and targets are set, and comes next is the planning requirements, which includes identifying the risks and opportunities, the energy review & improvement planning.

Energy data is then collected and made available for energy review and at the same time measurement & verification is done to ensure quality data.

Energy Review. To understand further how energy data is used in energy review, the EnMS approach is done on an Overall Site and the appropriate plant data is collected across the site and consolidated.

The first step is to account all the energy streams, and this includes fuel, steam, electricity, combustion of organic liquid wastes and waste gases, and waste heat streams. Each year a specific energy consumption is derived based on the energy intensity and forecasted production. All streams that fall under the energy intensive boundary i.e., Significant Energy Uses (SEUs) will further be evaluated whether that particular stream has the potential for further energy consumption reduction or not. If it has the potential, then the area owner is consulted as to whether an initiative is possible or if it has an existing project already. The next step is to prioritize these identified SEUs with potential improvements.

The outcome of energy review results in the identification of potential areas for improvement and determining which initiatives and projects need to be prioritized. The criteria for prioritization include compliance to regulatory and/or stakeholder requirement, impact on energy consumption reduction, project funding requirement, availability of technology, ease of implementation, and space requirement. Each of these considerations are scored and is ranked from the highest priority to the least. The initiatives are then incorporated to the annual energy improvement plan, which is submitted to the specific stakeholders for compliance reporting. Additionally, major projects undergo Techno-commercial feasibility study and employee standard project management tools, and other ideas are formally registered as an initiative in the centralized Innovate@ Tool.

“ISO 50001 is a valuable tool that empowers the Energy management system to enhance energy performance, unlock the full potential of energy efficiency, reducing cost and contributing to a sustainable future.”

—Mousa AlShaikhi, Production Director (Utilities)

The EnMS work process has been developed not only to fulfill the ISO 50001:2018 requirements, but also other company and stakeholder requirements, such as the existing Operating Discipline Management System (ODMS), the SEEC Framework, and results of assessments or audits. EnMS’ contribution to the Sustainability goals and targets is evident in the way how we systematize energy accounting, evaluation, reporting, and the entire loop of the continual

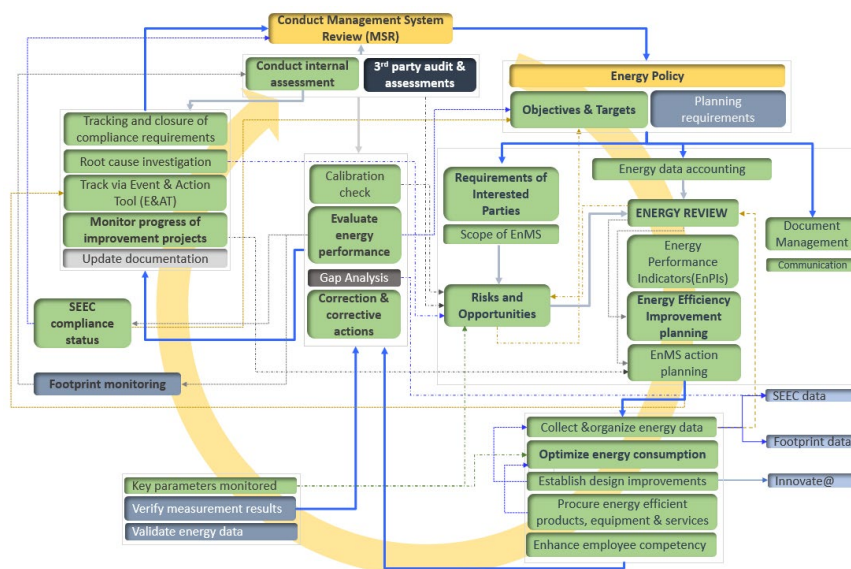


Figure 6. Sadara EnMS work process

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improvement work process. Additionally, EnMS is linked to the decarbonization activities since energy efficiency is the lowest hanging fruit where GHG reductions are tied up with energy consumption reduction. More specifically, the implementation of the energy improvement projects has a corresponding energy consumption reduction and an equivalent GHG reduction. In Sadara, we have established a number of energy streams with the equivalent GHG emission factors to calculate how much GHG is emitted from a particular stream.

Do, Check, and Act

EnMS implementation is done across the organization, and it starts with Top Management commitment and requirements are cascaded it to the hierarchy (see Figure 2). The Energy team charter indicates explicitly the roles and responsibilities. Leading the team is the sponsor, and his team is made up of an energy champion, a sustainability SME, and the energy focal points across the manufacturing plants and the supporting teams such as maintenance, engineering, and procurement. The team periodically meets to discuss the progress of the actions relative to the plan and any other continual improvement initiative.

Data consolidation. Energy data is obtained via the energy focal points from all facilities as well as the available centralized tool. Sadara uses licensed software to pull the energy data via a historian and this is eventually consolidated using an Excel-based calculation tool. A project is on-going to automate this system to facilitate faster data collection, analysis, and reporting. Monitoring of data is done on a monthly basis on a facility level and Overall Site level.

Energy improvement initiatives. At the very core of energy performance are the energy initiatives which have been implemented and made an impact on the Sadara energy footprint. We categorized these initiatives into 4: (1) Fuel consumption reduction, (2) Steam optimization, (3) Electricity reduction, and (4) other measures. Table 1 presents the initiatives implemented for 2023.

Table 1. Sadara energy improvement initiatives in 2023

1 Fuel reduction	2 Steam optimization	3 Electricity reduction	4 Other measures
Sadara Steam Generation Unit (SGU) has partially implemented the switching of Boilers Fuel from Gas & Liquid fuels to 100% Natural/Fuel gas. The intent was to reduced GHG emissions and enhance boiler operation efficiency by reducing the amount of waste generated from burning liquid fuel.	Absorber water flow optimization, Line up HP steam to steam turbine directly after reactor startup in Isocyanates to minimize venting of steam, Optimization of steam consumption in Isocyanates stripper columns, Aromatics MP condensate header optimization, Steam optimization in Aniline tower by increasing steam export and decreasing consumption, Reboiler Control Scheme improvement that reduced LP Steam consumption, New condensate line that routed condensate from trench to returned condensate header.	Optimization of requirement of Secondary Vacuum pump Isocyanates, Shutdown of Reverse Osmosis Unit (RO Unit) Isocyanates, Power saving by stopping fan motor for Atmospheric condensate vent cooler in Isocyanates plant during winter, Install Pressure controller in atmospheric compressor in Isocyanates to reduce power, Stopping flash tank pump to save power, Tail Gas rerouting to WGH that stopped the Tail Gas Compressor, LED upgrade of specific Sadara buildings.	Optimization of crude recycle in Isocyanates, EO Cycle gas rerouting.
Energy reduction: 1,586,537 GJ	284,580 GJ	379,746 GJ	42,097 GJ
GHG reduction 126,322 tons CO ₂ -eq.	23,419 tons CO ₂ -eq	59,916 tons CO ₂ -eq.	9,810 tons CO ₂ -eq.

Evaluation of energy & GHG performance. To evaluate our energy performance, including GHG performance, the base year of 2020 has been chosen, which is aligned with Top Management directive as per the Sadara Sustainability strategy. Additionally, 2020 is representative of the design operating rate, where Sadara is running at 100% without any pit stops and/or major unplanned events. Additionally, there are 2 main metrics defining the extent of our energy performance, the energy intensity (EI, expressed as Gigajoule GJ/ton) and the energy consumption (expressed as GJ). GHG metrics follows the same methodology, using the following formulas:

$$\text{Total Energy consumption (GJ)} = \Sigma \text{ energy consumed} - \Sigma \text{ energy exported}$$

$$\text{Energy intensity} \left(\frac{\text{GJ}}{\text{metric ton}} \right) = \frac{\text{Total Energy consumption}}{\text{Total products sold}}$$

$$\text{Total absolute GHG emissions (metric tons CO}_2\text{-eq)} = \text{Scope 1} + \text{Scope 2 emissions}$$

$$\text{GHG intensity} \left(\frac{\text{metric ton CO}_2\text{-eq}}{\text{metric ton products}} \right) = \frac{\text{Total absolute GHG emissions}}{\text{Total products sold}}$$

$$\text{Energy or GHG reduction (\%)} = \frac{\text{Value in } x \text{ year in consideration} - \text{Base year data (2020)}}{\text{Base year data (2020)}}$$

The main relevant variable is the production rate, other variables (such as weather) have been considered but the impact is incomparable to the production rate when annual data is evaluated.

EnMS Operational Control. To effectively implement operational control for each of the SEUs, Sadara has developed standards and procedures as mentioned in this document and specific work instructions either on a process level or equipment level is available in the ODMS portal. Changes in equipment or process setting cannot be done unless the Management of Change (MOC) process is completed electronically via an in-house Tool. Additionally, maintenance controls, procedures, and programs are in place. Apart from these administrative controls, engineering controls such as physical controls are in place. Additionally, appointing competent energy focal points and enhancing their technical and EnMS skills are done periodically.

The training and competency enhancement program for the energy focal points is done periodically and systematized by the Human Capital Development (HCD) department. Training needs are identified and reviewed during the end of year meeting and MSR. The energy team also launched awareness programs and e-flyers to other employees that impact the energy performance, while they may not necessarily be in the frontlines of control or planning, these employees contribute to the daily operations of the facilities. In-house technical workshops and events are also avenues to enhance and engage the employees.

Energy data independent assurance. To ensure the quality of our energy data reporting, energy data is subject to a 3rd party independent assessment, which is in line with the Sustainability data assessment. The assurance statement is provided in our annual [Sustainability Report](#), which details the findings of the assessment. There have been no major non-conformance with regards to how we account our energy consumption and energy intensity.

EnMS aspect in procurement. On the procurement of energy efficient products and services, an enhanced awareness on the proponent side has been observed and this is evident on the way how they order products (such as spare parts or like-for-like equipment) and services. Specific EnMS criteria is included during the procurement process, including clear definition in the material and/or project scoping.

External EnMS audit. To effectively check the health of the EnMS, annually an external audit is planned and conducted. Preparation is done by the energy team via meetings, workshops, and gap analysis. Where necessary, management support is needed to resolve any gap. Preparation usually take 2 to 3 months ahead of the 3rd party audit, including the basic requirements such as the audit plan and administrative requirements.

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Other EnMS performance KPIs. Apart from energy and costs, the environmental impact is being monitored and measured as a result of energy use, the number of employees who participated in the awareness, the energy focal point's attendance to the assigned training, the number of papers or abstract presented in workshops or conferences, number of energy audits, and the internal and external audit findings and closure.

Employee recognition. In order to fuel motivation across energy focal points, Sadara has strategies to facilitate recognition. These includes, the Balance of Consequences (BOC) where a designated committee evaluates the individual and corresponding score rates the individual and the impact to the company, the financial and other reward form is commensurate to the impact of the action; periodic Departmental recognition; through Success Factors, where performance is tied to the individual goals and the achievement of it; annual energy team recognition; and through random recognition, such as the CEO awarding those members who excelled in optimization of the waste heat recovery systems.



Figure 7. CEO recognizing the energy team for winning the GPCA 'Sustainable Environmental Protection Award' for its Sustainable Energy on Waste Heat Recovery

Transparency

Sadara ISO 50001:2018 certification is publicly reported via the [Annual Sustainability Report](#). The ISO 50001:2018 certificate is also posted on Sadara's external website. <https://www.sadara.com/en/About/Citizenship>

What We Can Do Differently

EnMS continual improvement is a journey. EnMS aspects that were not considered but could have enhanced implementation include: (1) integration of EnMS aspects during employee on-boarding, (2) regular networking with industry peers to understand how they effectively implement their EnMS and what new technologies are applicable to the company and (3) development of technical trainings in house that is specific to a particular discipline.

As for the future on EnMS implementation, we foresee continual improvement in our processes to meet our stakeholder requirements and enhanced energy performance, such as establishing specific KPIs for the SEUs. Sadara has planned 2 major projects beyond 2025 which will further enhance energy performance and reduce GHG emissions. Decarbonization is the list of top priorities and energy efficiency is at the front of the levers.



The Energy Management Leadership Awards is an international competition that recognizes leading organizations for sharing high-quality, replicable descriptions of their ISO 50001 implementation and certification experiences. The Clean Energy Ministerial (CEM) began offering these Awards in 2016. For more information, please visit www.cleanenergyministerial.org/EMAwards.